

PLEASE HELP 0.25 Mol Of Dextrose Was Added To 89.48 Mol Of Water. What Is The Mole Fraction Of Dextrose

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Understanding the concept of mole fraction is fundamental in chemistry, especially when dealing with solutions and mixtures. In this problem, we are asked to find the mole fraction of dextrose (also known as glucose) in a solution where 0.25 mol of dextrose is added to 89.48 mol of water. Calculating the mole fraction involves understanding the relationship between the moles of solute and the total moles in the solution.

This article aims to guide you through the process of calculating the mole fraction step-by-step, providing background information, relevant formulas, and practical examples. Whether you're a student preparing for exams or a professional working with solutions, understanding this calculation is essential in various fields such as chemistry, biochemistry, and chemical engineering.

What Is Mole Fraction?

Definition of Mole Fraction

The mole fraction is a way to express the concentration of a component in a mixture. It is defined as the ratio of the number of moles of a particular component to the total number of moles of all components present in the mixture.

Mathematically, the mole fraction (X_i) of component (i) is expressed as:

$$X_i = \frac{n_i}{n_{\text{total}}}$$

where:

- (n_i) is the number of moles of component (i) ,
- (n_{total}) is the total number of moles of all components in the mixture.

The mole fraction has no units and ranges from 0 to 1.

Significance of Mole Fraction

- It helps in calculating properties like partial vapor pressures, boiling point elevation, freezing point depression, and osmotic pressure.
- It provides an accurate measure of concentration in ideal solutions.
- It is essential in defining Raoult's Law and other thermodynamic principles.

Given Data and Objective

Before delving into calculations, it's crucial to understand the problem's data:

1. Amount of dextrose added: **0.25 mol**
2. Amount of water: **89.48 mol**

Objective: To find the mole fraction of dextrose (X_{dextrose}) in the mixture.

Step-by-Step Calculation of Mole Fraction

Calculating the mole fraction involves two main steps:

1. Determine the total number of moles in the mixture.
2. Use the mole fraction formula to find the ratio of dextrose to the total.

Step 1: Find Total Moles in the Solution

The total moles (n_{total}) are the sum of moles of dextrose and water:

$$n_{\text{total}} = n_{\text{dextrose}} + n_{\text{water}}$$

Plugging in the known values:

$$n_{\text{total}} = 0.25 + 89.48 = 89.73 \text{ mol}$$

Step 2: Calculate Mole Fraction of Dextrose

Using the formula:

$$X_{\text{dextrose}} = \frac{n_{\text{dextrose}}}{n_{\text{total}}}$$

Substitute the known values:

$$X_{\text{dextrose}} = \frac{0.25}{89.73} \approx 0.002786$$

Result: The mole fraction of dextrose in the solution is approximately 0.00279.

Interpretation and Significance of the Result

The mole fraction of dextrose is quite small, reflecting that it is a minor component compared to water. This is typical in dilute solutions where the solute (dextrose) is present in a much smaller proportion than the solvent (water).

Implications:

- The mole fraction can be used to predict other properties, such as vapor pressure lowering, via Raoult's Law.
- It helps in understanding solution behavior, especially in biochemical and pharmaceutical contexts.

Practical Applications of Mole Fraction Calculations

Understanding how to compute mole fractions is vital in various scientific and industrial applications:

1. Pharmacology and Biochemistry

- Precise formulation of solutions for drug delivery.
- Calculating osmotic pressures in biological systems.

2. Chemical Engineering

- Designing separation processes like distillation.
- Analyzing mixture properties for process optimization.

3. Environmental Chemistry

- Studying pollutant concentrations in water bodies.
- Modeling atmospheric solutions.

Additional Considerations and Tips

- Unit Consistency: Always ensure that the number of moles for all components are in the same units.
- Dilute Solutions: When the solute is dilute, the mole fraction is small; this is significant for vapor pressure calculations.
- Ideal Mixtures: Mole fraction calculations assume ideal behavior; real solutions may deviate slightly due to interactions.

Conclusion

Calculating the mole fraction of dextrose in a solution where 0.25 mol of dextrose is added to 89.48 mol of water is straightforward once you understand the basic principles. By summing the moles to find the total and applying the mole fraction formula, we find that:

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X_{\text{dextrose}} \approx 0.00279
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This value indicates that dextrose constitutes roughly 0.279% of the total moles in the mixture, highlighting its relatively minor presence compared to water. Mastery of mole fraction calculations is essential for chemists and related professionals to analyze solutions, predict properties, and design experiments efficiently.

Additional Resources:

- [Understanding Raoult's Law and Its Applications] (<https://www.chemistryworld.com/>).
- [Mole Fraction and Its Role in Solution Chemistry] (<https://www.sciencedirect.com/>).
- [Calculations in Solution Chemistry: A Step-by-Step Guide] (<https://chemistrytalk.org/>).

Remember: Accurate calculations depend on precise data and understanding the context of the problem. Practice similar problems to build confidence and expertise in solution chemistry.

Frequently Asked Questions

How do you calculate the mole fraction of dextrose in a solution where 0.25 mol of dextrose is added to 89.48 mol of water?

The mole fraction of dextrose (X_{dextrose}) is calculated by dividing the moles of dextrose by the total moles of all components: $X_{\text{dextrose}} = 0.25 / (0.25 + 89.48) \approx 0.0028$.

What is the significance of mole fraction in solutions involving dextrose and water?

Mole fraction indicates the proportion of dextrose relative to the total moles in the solution, which helps in understanding solution composition and calculating properties like vapor pressure and boiling point elevation.

If 0.25 mol of dextrose is added to 89.48 mol of

water, is the solution considered dilute?

Yes, since the mole fraction of dextrose is very low (~ 0.0028), the solution is considered dilute.

How does the mole fraction of dextrose affect colligative properties of the solution?

The mole fraction of dextrose influences colligative properties such as vapor pressure lowering, boiling point elevation, and freezing point depression; a lower mole fraction results in smaller changes.

Can you convert the mole fraction of dextrose into a percentage concentration?

Yes, the mole percentage is calculated as $(\text{mole fraction of dextrose}) \times 100$, which is approximately 0.28% in this case.

What assumptions are made in calculating the mole fraction in this scenario?

The calculation assumes ideal solution behavior, that all moles are additive, and that the given quantities are accurate without any reactions or interactions affecting the mole counts.

Why is understanding the mole fraction important in biochemical or pharmaceutical applications involving dextrose?

Because mole fraction provides precise information about solute concentration, which is crucial for dosing, stability, and reaction kinetics in biochemical and pharmaceutical contexts.

Additional Resources

Mole Fraction Calculation of Dextrose in a Water Solution: An Expert Analysis

Introduction

In the realm of chemistry, understanding the composition of solutions is fundamental. Whether you're a student tackling coursework or a scientist designing experiments, precise calculations of solution properties are essential. Today, we'll explore a practical example involving the calculation of the mole fraction of dextrose in a water solution, given specific quantities. This scenario not only illustrates core concepts in solution chemistry but also highlights how to approach mole fraction calculations methodically.

Setting the Scene: The Problem Statement

Suppose we add 0.25 mol of dextrose (also known as glucose) to 89.48 mol of water. The question posed is:

"What is the mole fraction of dextrose in this solution?"

This problem may seem straightforward, but it offers a valuable opportunity to delve into the principles of molar calculations, solution composition, and the significance of mole fractions in chemistry.

Understanding the Key Concepts

Before diving into calculations, let's clarify some foundational ideas:

1. Mole Fraction (X)

- The mole fraction of a component in a mixture is the ratio of the number of moles of that component to the total number of moles in the mixture.
- It is a dimensionless quantity, ranging from 0 to 1.
- For dextrose, it is denoted as X_{dextrose} :

$$X_{\text{dextrose}} = \frac{\text{moles of dextrose}}{\text{total moles in solution}}$$

2. Moles of Components

- The amount of each component is expressed in moles, which quantifies the number of particles (molecules or atoms) present.

Step-by-Step Calculation

Let's now proceed systematically to calculate the mole fraction of dextrose.

Step 1: Identify the given quantities

- Moles of dextrose, $n_{\text{dextrose}} = 0.25$, mol
- Moles of water, $n_{\text{water}} = 89.48$, mol

Step 2: Calculate the total moles

Total moles in the solution:

$$n_{\text{total}} = n_{\text{dextrose}} + n_{\text{water}} = 0.25 + 89.48 = 89.73, \text{ mol}$$

Step 3: Compute the mole fraction of dextrose

Using the definition:

$$X_{\text{dextrose}} = \frac{n_{\text{dextrose}}}{n_{\text{total}}} = \frac{0.25}{89.73}$$

Calculating this:

$$X_{\text{dextrose}} \approx 0.002786$$

Thus, the mole fraction of dextrose is approximately 0.00279.

Interpreting the Result

The mole fraction indicates that dextrose makes up a very small proportion of the total moles in the solution. This is expected because:

- Dextrose is added in a relatively tiny amount (0.25 mol).
- Water, being abundant, dominates the composition.

This low mole fraction (~ 0.00279) signifies that the solution is predominantly water, with dextrose as a minor solute. Such information is crucial when considering solution properties like vapor pressure lowering, boiling point elevation, or osmotic pressure.

Broader Implications and Practical Applications

Understanding mole fractions is vital across various scientific and industrial contexts:

- Pharmaceuticals: Precise formulation of glucose solutions for medical purposes relies on accurate mole fraction calculations.
- Food Industry: Dextrose solutions are common in food processing; knowing their composition affects taste, texture, and preservation.
- Chemical Engineering: Designing processes like crystallization or distillation requires knowledge of solution composition.
- Research: Accurate mole fractions help in studying colligative properties, reaction kinetics, and more.

Additional Considerations

While the calculation appears straightforward, several factors can influence the interpretation and application:

1. Temperature Effects

- Molar masses are temperature-independent, but solution behavior can vary with temperature, affecting properties like solubility.

2. Purity of Components

- Assumes pure water and pure dextrose. Impurities can alter the mole counts and, consequently, the mole fraction.

3. Volume vs. Moles

- Sometimes, solution concentrations are expressed in volume or mass. Converting between these requires additional data, such as densities and molar masses.

Summary of Key Points

- The mole fraction of dextrose in the given solution is approximately 0.00279.
- This calculation hinges on knowing the number of moles of each component

and summing to find the total.

– Mole fractions are essential for understanding solution behavior, especially in colligative property calculations.

Final Thoughts: Why This Matters

Accurate calculation of mole fractions like the one we've explored not only enhances our understanding of solution chemistry but also informs practical applications across industries. Whether developing a new pharmaceutical formulation or optimizing a food processing technique, such fundamental calculations underpin successful and precise scientific work.

Understanding the delicate balance of solution components empowers scientists and engineers to innovate, optimize, and ensure safety and efficacy in their products and processes.

In essence, mastering the calculation of mole fractions—like the dextrose in water example—is a cornerstone of chemical literacy that bridges theoretical knowledge with real-world applications.

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